ASE 7 - Heating & Air Conditioning

Module 6
Cooling Systems
Acknowledgements

General Motors, the IAGMASEP Association Board of Directors, and Raytheon Professional Services, GM's training partner for GM's Service Technical College wish to thank all of the people who contributed to the GM ASEP/BSEP curriculum development project 2002-3. This project would not have been possible without the tireless efforts of many people. We acknowledge:

- The IAGMASEP Association members for agreeing to tackle this large project to create the curriculum for the GM ASEP/BSEP schools.
- The IAGMASEP Curriculum team for leading the members to a single vision and implementation.
- Direct contributors within Raytheon Professional Services for their support of translating a good idea into reality. Specifically, we thank:
  - Chris Mason and Vince Williams, for their leadership, guidance, and support.
  - Media and Graphics department under Mary McClain and in particular, Cheryl Squicciarini, Diana Pajewski, Lesley McCowey, Jeremy Pawelek, & Nancy DeSantis.
  - For his help on the Heating, Ventilation, and Air Conditioning curriculum volume, Subject Matter Expert, Brad Fuhrman, for his wealth of knowledge.

Finally, we wish to recognize the individual instructors and staffs of the GM ASEP/BSEP Colleges for their contribution for reformatting existing General Motors training material, adding critical technical content and the sharing of their expertise in the GM product. Separate committees worked on each of the eight curriculum areas. For the work on this volume, we thank the members of the Heating, Ventilation, and Air Conditioning committee:

- Steve Ash, Sinclair Community College
- Warren Farnell, Northhampton Community College
- Rick Frazier, Owens Community College
- Marvin Johnson, Brookhaven College
- Chris Peace, J. Sargeant Reynolds Community College
- Vince Williams, Raytheon
Introduction

After completing this unit, the technician will demonstrate an understanding of automotive coolant systems. The technician will also demonstrate the skills required to troubleshoot and replace automotive coolant system components.

Objectives

- Understand the theory and operation of typical cooling systems
- Understand the construction and components of a typical cooling system
- Demonstrate successful troubleshooting skills on cooling systems

NATEF Area VI. A.

1. Identify and interpret heating and air conditioning concern; determine necessary action
2. Research applicable vehicle and service information, such as heating and air conditioning system operation, vehicle service history, service precautions, and technical service bulletins.
3. Locate and interpret vehicle and major component identification numbers (VIN, vehicle certification labels, calibration decals).
4. Performance test A/C system; diagnose A/C system malfunctions using principles of refrigeration.
5. Identify refrigerant type; conduct a performance test of the A/C system; determine necessary action.
6. Leak test A/C system; determine necessary action.
7. Inspect the condition of discharged oil; determine necessary action.
8. Determine recommended oil for system application
9. Inspect A/C condenser for airflow restrictions; perform necessary action.
10. Remove and reinstall receiver/drier or accumulator/drier; measure oil quantity; determine necessary action.
11. Remove and install expansion valve or orifice (expansion) tube.
12. Inspect evaporator housing water drain; perform necessary action.
13. Perform cooling system, cap, and recovery system tests (pressure, combustion leakage, and temperature); determine necessary action.
14. Inspect engine cooling and heater system hoses and belts; perform necessary action. Inspect, test, and replace thermostat and housing.

15. Determine coolant condition and coolant type for vehicle application; drain and recover coolant. Flush system; refill system with recommended coolant; bleed system.

16. Perform correct use and maintenance of refrigerant handling equipment.

17. Identify (by label application or use of a refrigerant identifier) and recover A/C system refrigerant.

18. Recycle refrigerant.

19. Label and store refrigerant.

20. Test recycled refrigerant for non-condensable gases.


**STC Tasks:**

Describe cooling system components
Describe cooling system functions
Describe the air distribution system used in HVAC systems
Lesson 1. Theory and Operation

Cooling System Overview
The cooling system circulates coolant through engine passages to absorb combustion heat and pumps the hot coolant to the radiator, located at the front of the vehicle, to release the heat to the outside air. The following components make up the cooling system:

Air Intake
- Ambient air flows across the condenser/radiator
- Pushed by forward vehicle movement and pulled by cooling fans.
- Fan shrouds and seals maximize the amount of air intake for cooling.

Condenser/Radiator
- Each transfers absorbed heat to the incoming ambient air by radiation from finned surfaces.
- The condenser releases heat absorbed in the refrigerant.
- The radiator releases heat absorbed in the coolant.

Fan(s)
- GM vehicles use a belt driven or electric cooling fan(s).

Coolant
- Coolant flows through engine passages to absorb combustion heat.
Heater Core

- Hot coolant flows through this heat exchanger
- Located in the HVAC module
- To heat the vehicle's interior during cold weather.
- Or to blend with conditioned air for a desired temperature during moderate weather.

Other Components: Thermostat, Radiator Cap, Overflow Tank, Surge Tank, Coolant Pump and Hoses/Clamps

- Thermostat
  - Insures proper engine warm-up by staying closed until the coolant reaches temperature.
- Reservoir or Overflow bottle
  - Allows coolant expansion during operation.
- Surge Tank and Cap
  - Allows coolant expansion during operation.
  - Pressure cap seals the system.
- Water (Coolant) Pump
  - A belt-driven pump circulates coolant.
- Hoses and clamps
  - Proper operation of the cooling system depends on the hoses and clamps being in good condition.

Air Intake

- Air intake system directs air flow from outside the vehicle through the fins of the condenser and the radiator.
- Includes specific grille design, air dams, shrouds and seals to insure maximum airflow to the condenser and radiator.
- Any structural damage to the front-end of a vehicle will compromise the effectiveness of the air intake system.
- Any obstructions or blockages in this path can cause insufficient heat transfer at both the condenser and the radiator.
- Hidden blockage between the condenser and radiator is a problem.
- A damaged or missing fan shroud, or loose or missing air intake seals, can decrease the amount of cooling air by allowing some of the incoming air to pass around, not through, the condenser and radiator.
Radiator

- The radiator is mounted behind the condenser.
- As a result, the radiator must transfer heat from the coolant into already preheated air.

As a note, if the cooling system is not operating properly, excess heat may build up in the radiator and adversely affect the heat-transfer capability of the condenser.

- The radiator is a large heat exchanger with two sets of passages.
  - One set is for coolant flow
  - The other is for air flow
- As coolant is pumped through the radiator, the air passing through its fins removes heat.
- Heat dissipation at the radiator is affected by:
  - Vehicle speed
  - Cooling fan operation
  - Air intake system
  - Condenser heat load
- Most GM radiators are a cross-flow design.
  - Takes up less space than down-flow designs
  - Allows lower hood lines
  - Inlet and outlet tanks are on the ends
- Core construction may be tube-and-plate fin, tube-and-serpentine fin or cellular.
Electric Coolant Fan

- Coolant Fan operation generally occurs when:
  - Coolant temperature exceeds a certain temperature.
  - A/C system operation is requested.
  - The A/C coolant fan pressure switch closes at a certain compressor head pressure.
  - Pusher Fan
    - Fan mounted on the outboard side of the condenser.
  - Puller Fan
    - Fan mounted on the inboard side of the radiator.

Figure 6-4, Electric Coolant Fan

Coolant

- The coolant in the engine cooling system remains a liquid as it:
  - Soaks up combustion heat.
  - Circulates through the system to the radiator and heater core.
  - Releases its heat to the ambient air flowing across the radiator

- Coolant is a mixture of water and "antifreeze".
  - All cooling systems since 1997 are filled with a mixture of 50% water and 50% Dex-Cool Coolant.
    - Non-phosphate
    - Silicate free
    - Ethylene glycol-based antifreeze.
    - Recommended for aluminum engine protection and increased water pump seal life.
  - The mix is 50-50 water and antifreeze.
    - Mixtures with less than 30% antifreeze provide inadequate corrosion protection.
    - Mixtures with more than 67% antifreeze freeze quicker and have less heat-transfer ability.

Figure 6-5, Coolant
Other Coolant System Components

- Thermostat
- Surge Tank and Cap
- Water (Coolant) Pump
- Auxiliary Coolant Pump

**Thermostat**

- Located in the coolant passage.
- Remains closed during cold-start condition to allow engine to warm-up more quickly.
- Using the correct thermostat is critical for correct air-fuel ratios and timing.

![Figure 6-6, Thermostat](image)

**Heater Core**

- The heater core is a heat exchanger with two sets of passages. One set is for coolant flow the other is for air flow. As coolant is pumped through the heater core, the air passing through its fins removes heat into the vehicle's interior.
- Heat dissipation at the heater core is affected by:
  - Blower fan operation
  - Coolant flow

![Figure 6-7, Heater Core](image)
Surge Tank and Cap
• Mounted near the radiator.
• Uses a pressurized coolant surge tank.

Reservoir or Overflow Bottle
• Mounted near the radiator.
• Uses a plastic coolant overflow bottle.

Water (Coolant) Pump
• Mechanical pump mounted on engine to circulate coolant through engine passages to the radiator.
  – Accessory belt driven.
  – Must remove front timing belt cover for water pump service.
  – Must clean bolt holes out prior to reassembly. Can use thread chaser to clean bolt holes.
Hose and Clamp Inspection

- The proper operation of the cooling system depends on the hoses and clamps being in good condition.
- Yet, these items are often taken for granted and overlooked.
- When these oversights occur, roadside emergencies will follow, which will lead to low customer satisfaction.
- Proper physical and visual inspection of hoses and clamps can avoid these problems.

Figure 6-10, Hose and Clamp Inspection
Hoses should not only be checked by means of a thorough visual inspection, but also by squeezing each hose along its entire length. Look for these problems:

- **Sponginess:** If the hose collapses too easily as you feel along its length, replace it. It’s deteriorating.
- **Bulging or Swelling:** This means there has been weakening under pressure; Replace the hose.
- **Brittleness:** As you feel and wiggle the hose and it has a feeling of brittleness, replace the hose.
- **Cracking at the point of Attachment:** Replace the hose anytime you see this condition.

*Figure 6-11, When removing a hose for replacement, slit the hose end, twist left and right, then pull straight off.*

**Hose Replacement**

- When replacing hoses, reference the appropriate service manual for procedures.
- General tips on hose replacement
  - When removing a hose for replacement, slit the hose end, twist left and right, then pull straight off.
  - Dip ends of new hose into coolant for easier installation.
Draining and Filling Cooling System

Caution:
Under some conditions, the ethylene glycol engine coolant is combustible. In order to help avoid being burned, do not spill the antifreeze or the coolant on the exhaust system or the hot engine parts.

Caution:
Do not remove the radiator cap when the radiator is warm. Removing the cap immediately lowers the boiling point of the coolant, and could cause a violent overflow, resulting in a large coolant loss and personal injury.

Notice:
Alcohol, methanol-based coolants or plain water alone should not be used in the cooling system at any time. Damage to the cooling system could result from their use.

Important
Maintain the cooling system protection at -36°C (-33°F). This temperature will prevent corrosion and loss of coolant from boiling. Maintain this level of protection even if extreme temperatures are not expected.

The cooling system is filled (by the manufacturer) using a coolant that is a 50/50 mixture of water and ethylene glycol antifreeze. This coolant solution provides freezing protection to -36°C (-33°F).

Add ethylene glycol-based coolant to the coolant reservoir when the coolant level is low. Refer to the antifreeze proportioning chart and the coolant capacity chart.

1. Remove the radiator cap.

Important
Watch for a potential overheating condition while the engine is operating with the radiator cap off.

2. Start the engine. Run the engine for 15 minutes.
Important
Dispose of used coolant in a coolant holding tank which is picked up along with used oil.

Do not pour used coolant down the drain. Ethylene glycol antifreeze is a toxic chemical. Do not dispose of ethylene glycol antifreeze into the sewer system or ground water.

3. Stop the engine.
4. Open the drain plug on the radiator. Drain the coolant into a container.
5. Close the drain plug.
6. Fill the cooling system with water.
7. Repeat the drain and fill procedure until the drained water is clean.

Notice
Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

8. Close the radiator drain plug. **Tighten** the drain plug to 13 N•m (9 lb ft).
9. Remove the hose from the reservoir cap.
10. Remove the coolant reservoir assembly.
11. Drain the coolant from the coolant reservoir into a container.
12. Use soap and water in order to clean the inside of the coolant reservoir.
13. Thoroughly rinse the coolant reservoir.
14. Install the coolant fan and coolant reservoir assembly.
15. Prepare a 50/50 mixture of ethylene glycol coolant GM P/N 1052753 (or equivalent) and water.
16. Fill the radiator to the base of the radiator filler neck.
17. Fill the coolant reservoir to the FULL mark on the reservoir.
18. Install the reservoir hose to the reservoir cap.

**Important**
Watch for a potential overheating condition while the engine is operating with the radiator cap off.

19. Start and run the engine until the coolant is at operating temperature.
20. The coolant is at operating temperature when the following conditions exist:
   - The hoses feel warm
   - The coolant is moving in the radiator
21. Add coolant to the radiator until the coolant level reaches the radiator filler neck.
22. Install the radiator cap.
23. Inspect the following components for leaks:
   - The radiator
   - The coolant reservoir
   - The coolant pipe connections
   - The hose connections
24. Tighten any loose connections as necessary.
Pressure Cap Testing

Tools Required:
- Cooling System Pressure Tester

Caution:
To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Remove the pressure cap.
2. Wash the pressure cap sealing surface with water.

3. Use the Cooling System Tester in order to test the pressure cap.
4. Test the pressure cap for the following conditions:
   - Pressure release when the Cooling System Tester exceeds the pressure rating of the pressure cap.
   - Maintain the rated pressure for at least 10 seconds.
5. Replace the pressure cap under the following conditions:
   - The pressure cap does not release pressure which exceeds the rated pressure of the cap.
   - The pressure cap does not hold the rated pressure.
Cooling System - Worksheet

Objective: At the completion of this worksheet, the technician will be able to explain the functionality of various cooling system components.

Reference: Refer to Module 6 Cooling Systems student workbook.

Directions: Answer the following questions individually, then review in a class.

Questions for Review

1. What is the purpose of the air intake portion of the cooling system?
   
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

2. What is the purpose of the condenser within the cooling system?
   
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

3. What is the purpose of the coolant fans of the cooling system?
   
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

4. What is the purpose of the radiator within the cooling system?
   
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

5. What cooling system component provides a quick warm-up of the heater core and cockpit area?
   
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

Student Workbook

ASE 7 - Heating & Air Conditioning

Module 6 - Cooling Systems

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